Advanced Biomedical Collaboratory

Access Grid Retreat 2004

Ryerson University, Toronto, Canada

June 9th Showcase

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Outline of Talk

- Introduction to the ABC Lab

- Challenges motivating Distributed Medical Visualization by Access Grid

- Demonstration and slides describing technologies and features

- Conclusions and future work

ABC Lab Collaborators

- Participating Groups
  - Futures Laboratory of ANL
  - The Computation Institute of Argonne National Laboratory (ANL) and The University of Chicago
  - The University of Chicago Hospitals
  - UC Department of Surgery
  - UC Department of Anesthesia
  - UC Developing Center for Patient Safety
  - UC Department of Radiology
  - UC Department of Emergency Medicine
  - Rhode Island Hospital Medical Simulation Center
  - University of Illinois at Chicago Electronic Visualization Laboratory

- Advisory and contracted support
  - Clinicians at more than 5 other major medical centers nationally
  - General Devices
  - International Emergency Medicine Disaster Specialists
  - Peter Jurek
  - Sapien Systems
  - William McGaghie

- Direct Funding
  - National Library of Medicine
  - University of Chicago
    - Provost Program for Academic Technology Innovations
    - University of Chicago Hospitals
    - Department of Surgery

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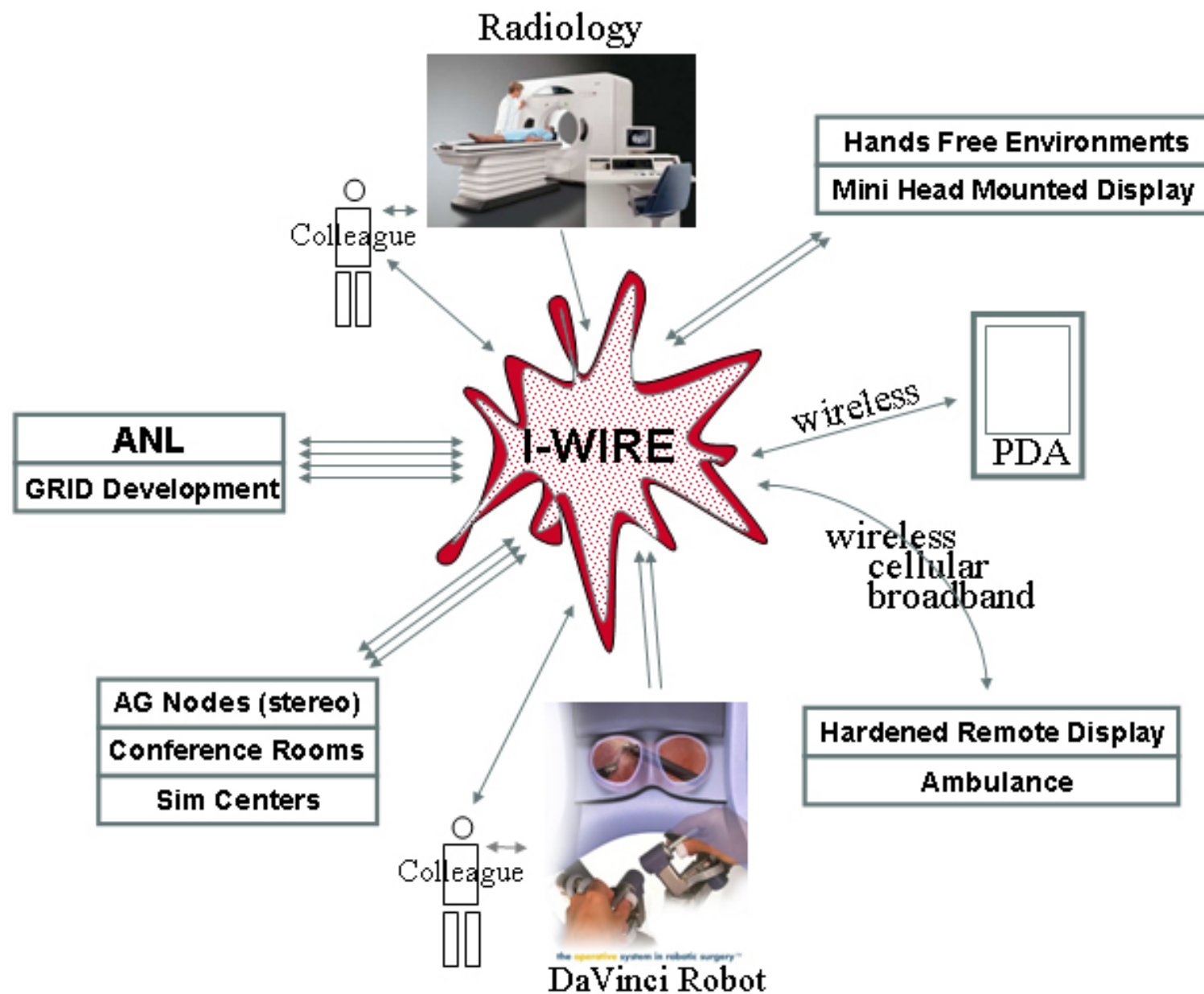# Advanced Biomedical (Tele)-Collaboration

Synchronous participation among biomedical professionals in complex environments (at distributed locations)

Key area of focus for us: Convergence of visualization and networking technologies in biomedicine

Advanced Biomedical Collaboration Testbed (ABC Testbed)

- Biomedical research, education, and the practice of medicine have become socially complex, team-oriented activities with the associated danger of dis-coordination under adverse conditions.

- Advanced biomedical tele-collaboration combines
  - Grid computation
  - Mobile computing platforms
  - Compelling scientific visualization
  - Applications that permit collaborators to see each other in real time (AG)
  - Remote control/distributed computing
  - Computer-in-the-loop instrumentation
  - Colleague-in-the-loop instrumentation

- Biomedical tele-collaboration is perfectly analogous to tele-medicine except that the people who are collocating are all biomedical professionals sharing scientific, didactic or clinical information colored by their own experience.

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Radiology

Colleague

Hands Free Environments

Mini Head Mounted Display

I-WIRE

ANL

GRID Development

wireless

PDA

wireless cellular broadband

AG Nodes (stereo)

Conference Rooms

Sim Centers

Hardened Remote Display

Ambulance

Colleague

DaVinci Robot

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Identified Challenges in Surgical Education and Practice

- Rapid expansion of knowledge
- Limited availability of biological materials for training and simulation
- Limited availability of expert surgeons
- Increasingly specialized procedures
- Application of teleconferencing, telepresence, and virtual reality as solutions

Three-Dimensional Anatomy

- Highly complex
- Critical to understanding common problems
- Surgeon's conceptual visualization difficult to achieve with 2D illustrations or photos
- Cadaver dissection is even difficult

- Our Prior Solution: Manipulate Computer-Generated Visualizations in Networked ImmersaDesks (using Globus Toolkit)

Immersive Hepatic Surgery Educational Environment (IHSEE)

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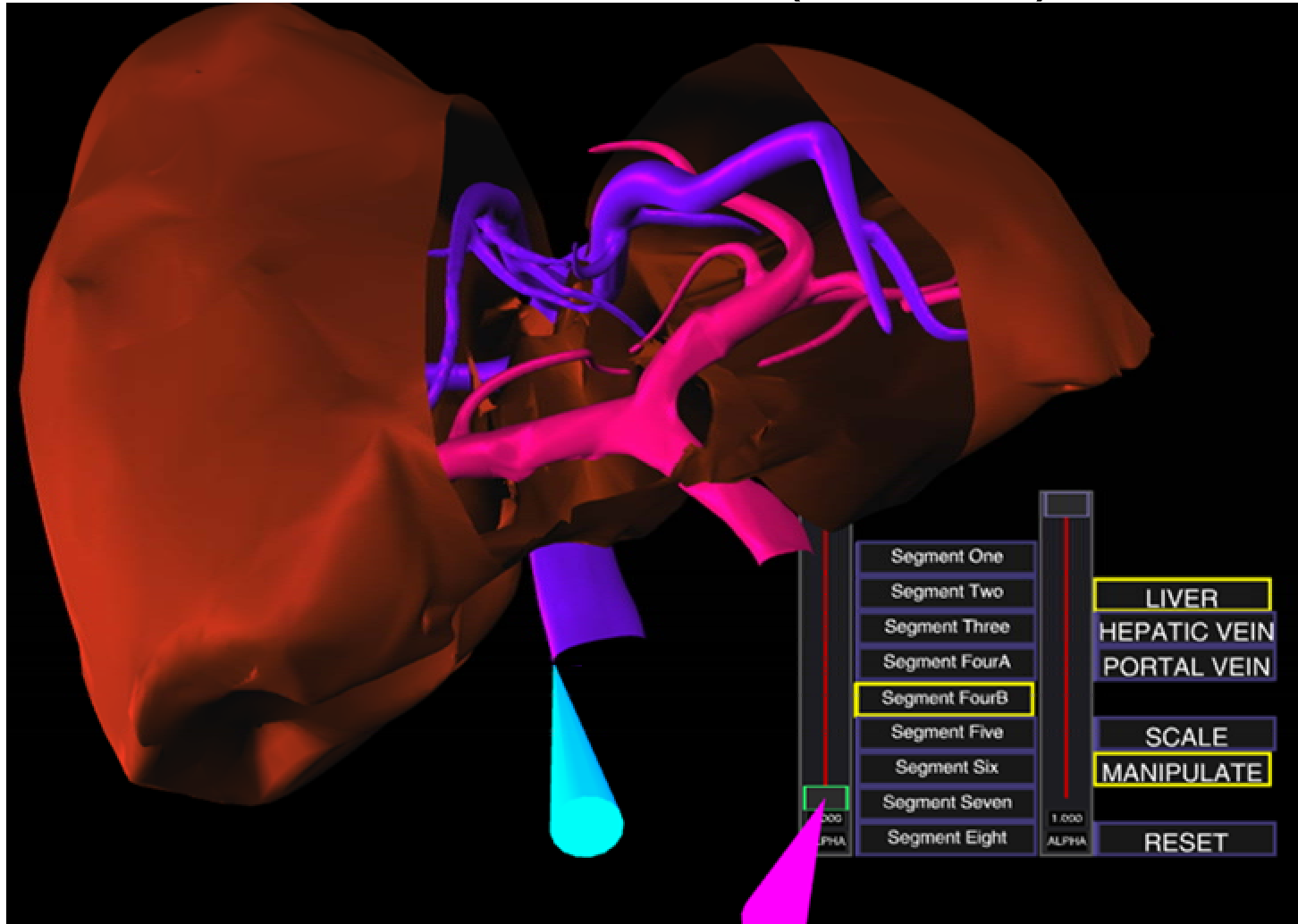
Challenges in Radiological Visualization

- Rapid expansion of knowledge and tools
  - Data will be so voluminous that it will become impossible to interpret without advanced visualization techniques
    - For example: New Philips 40-slice CT scanner coming to UCH
- Conformance to standards historically poor
  - DICOM as solution
- Limited availability of expert radiologists
  - Increasingly specialized procedures requiring surgeon direct access to visualization tools and colleagues in real time to generate detailed patient-specific visualizations
- Visualization technically complicated
  - Multiple locations for acquisition, pre-processing, and display
  - "larger than desktop" visualization engines
  - Security issues
- Solution: Application of Access Grid and other Grid technologies

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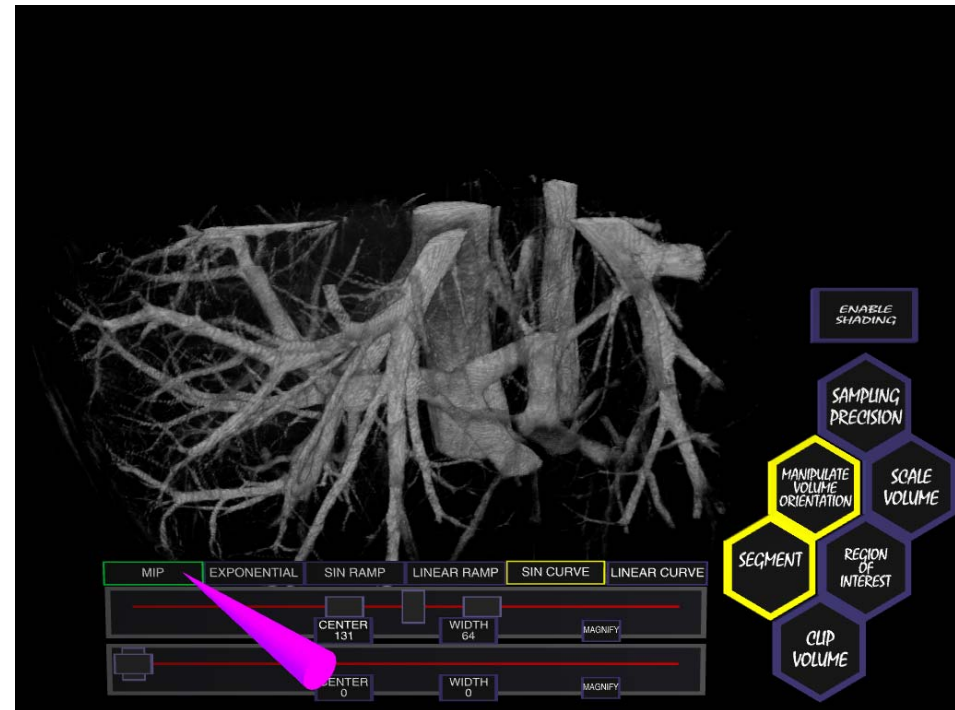# Rigorous Exploration of Medical Data in Collaborative Virtual Reality Applications

Distributed, collaborative, stereoscopic visualization and high precision manipulation of volumetric data

Collaborators:

Depts. of Radiology, UIC and UC

Electronic Visualization Lab, UIC

Math & Computer Science Div., ANL

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Collaborative Virtual Reality Features Implemented

- Persistent Server-Client Tele-Collaboration
  - Distributed application control, Synchronization, Audio and video channels sharing
- Model selection, Transparency of Elements
- Translate, Rotate, Scale
- Automatic DICOM import
- Segmentation
- Region of Interest
- Sampling Precision
- Arbitrary Clipping Plane

Visible Human Female 2048x1024xRGB
-subsampled to 128x128x117 (~1.3mmvoxels)
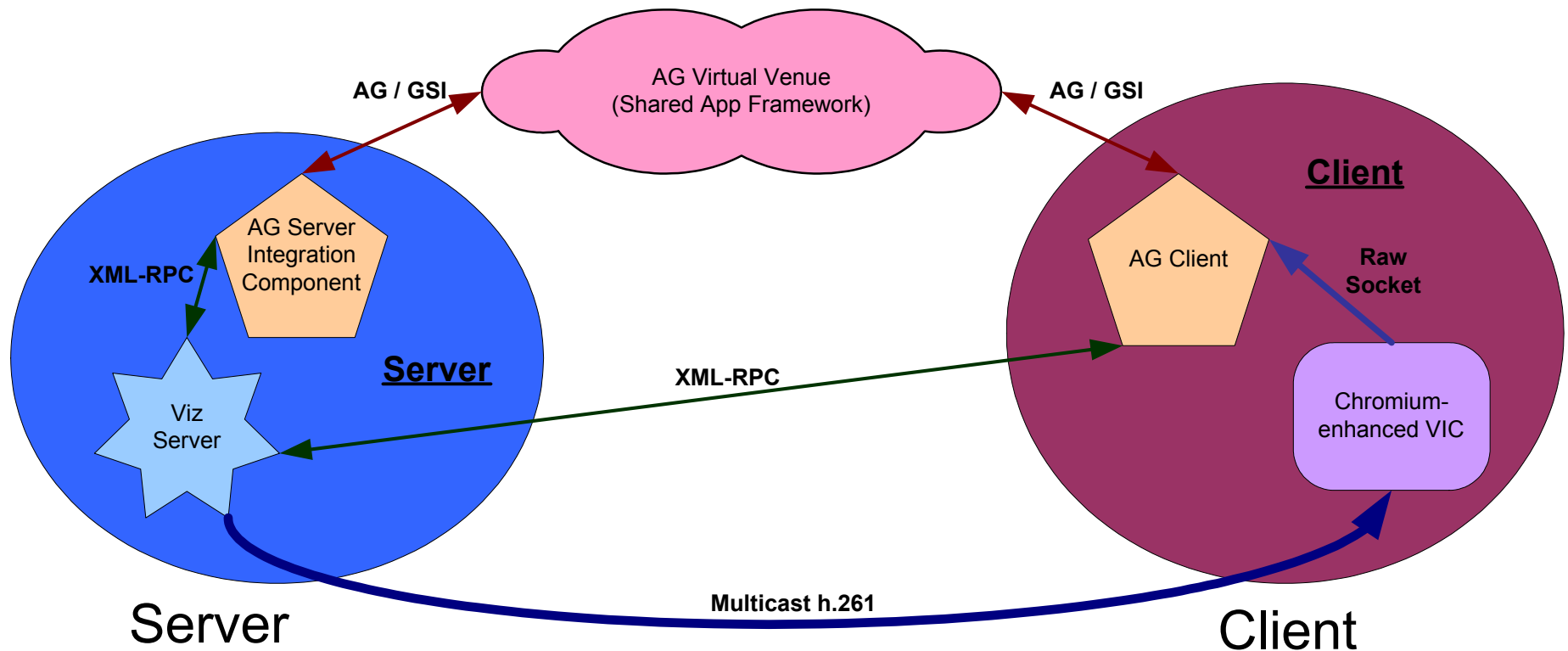

R G B

invert
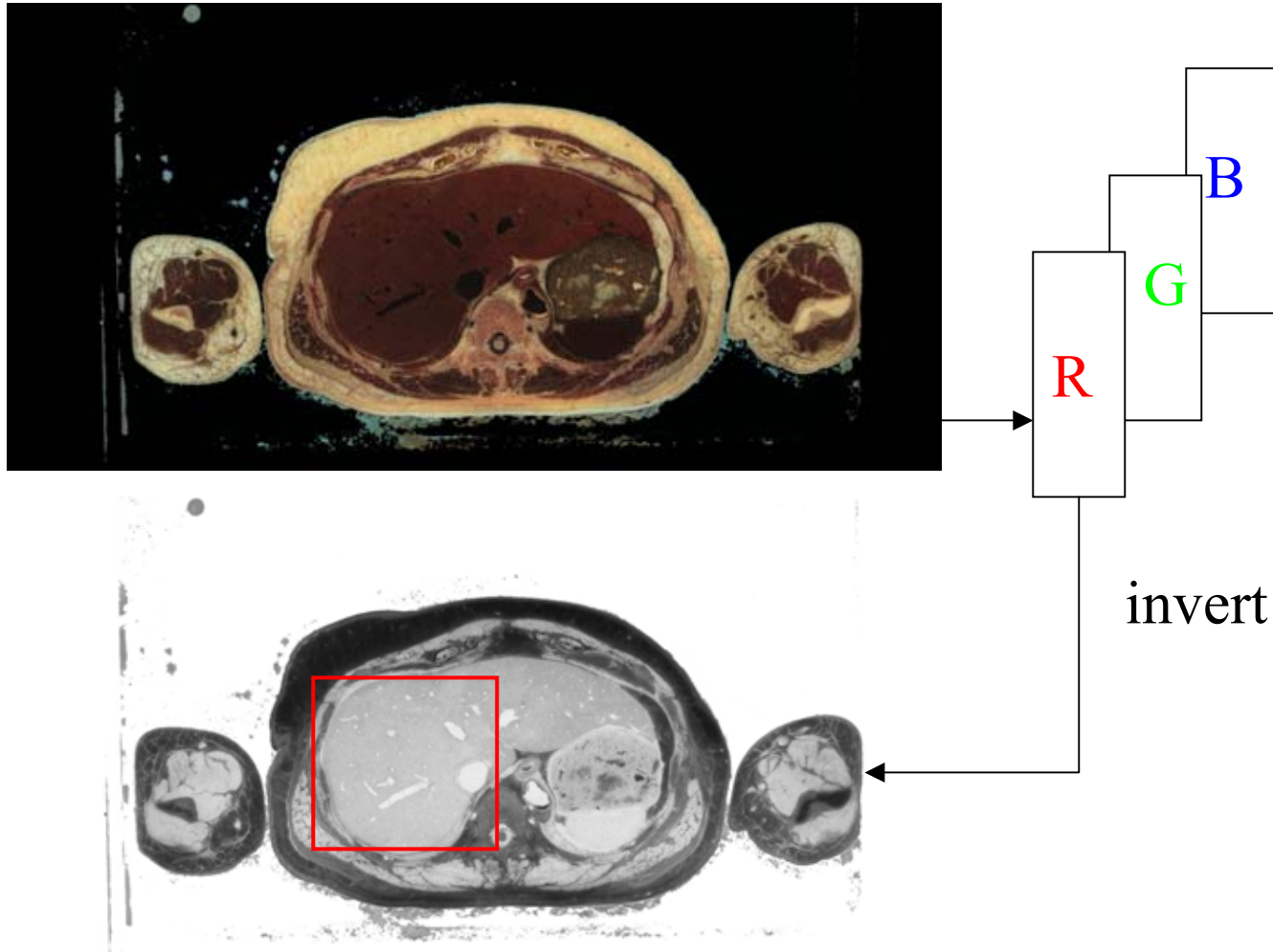
DICOM Data (clinical acquisition)

- MR Angiogram – Magnetic Resonance Imaging enhanced with Gadolinium

- 56 slices

- Coronal sections

- In plane resolution: 1.3mm pixels

- Slice resolution: 1.2mm

- Volumetric resolution: 256x256x56

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Distributed Medical Visualization: Framework Diagram

AG / GSI

AG Virtual Venue
(Shared App Framework)

AG / GSI

Client

AG Server
Integration
Component

XML-RPC

AG Client

Raw
Socket

Server

Viz
Server

XML-RPC

Chromium-
enhanced VIC

Server

Multicast h.261

Client

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Distributed Medical Visualization: Framework Overview

- Four essential components
  - Visualization server
  - Server-side AG integration component
  - Client-side AG integration component and GUI
  - Specialized VIC for client-side visualization display
- Access Grid used for GUI synchronization and application startup
- Out-of-band (XML-RPC) communication used for handling of high-frequency events and server state changes (i.e., mouse events)

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Distributed Medical Visualization: Server Component

- Visualization Server
  - Utilizes XML-RPC interface for control
  - Utilizes Chromium / FLX for high-resolution shared display
  - Utilizes VTK for volume rendering

- Server-side AG integration
  - Provides necessary startup information in AG Shared Application data space
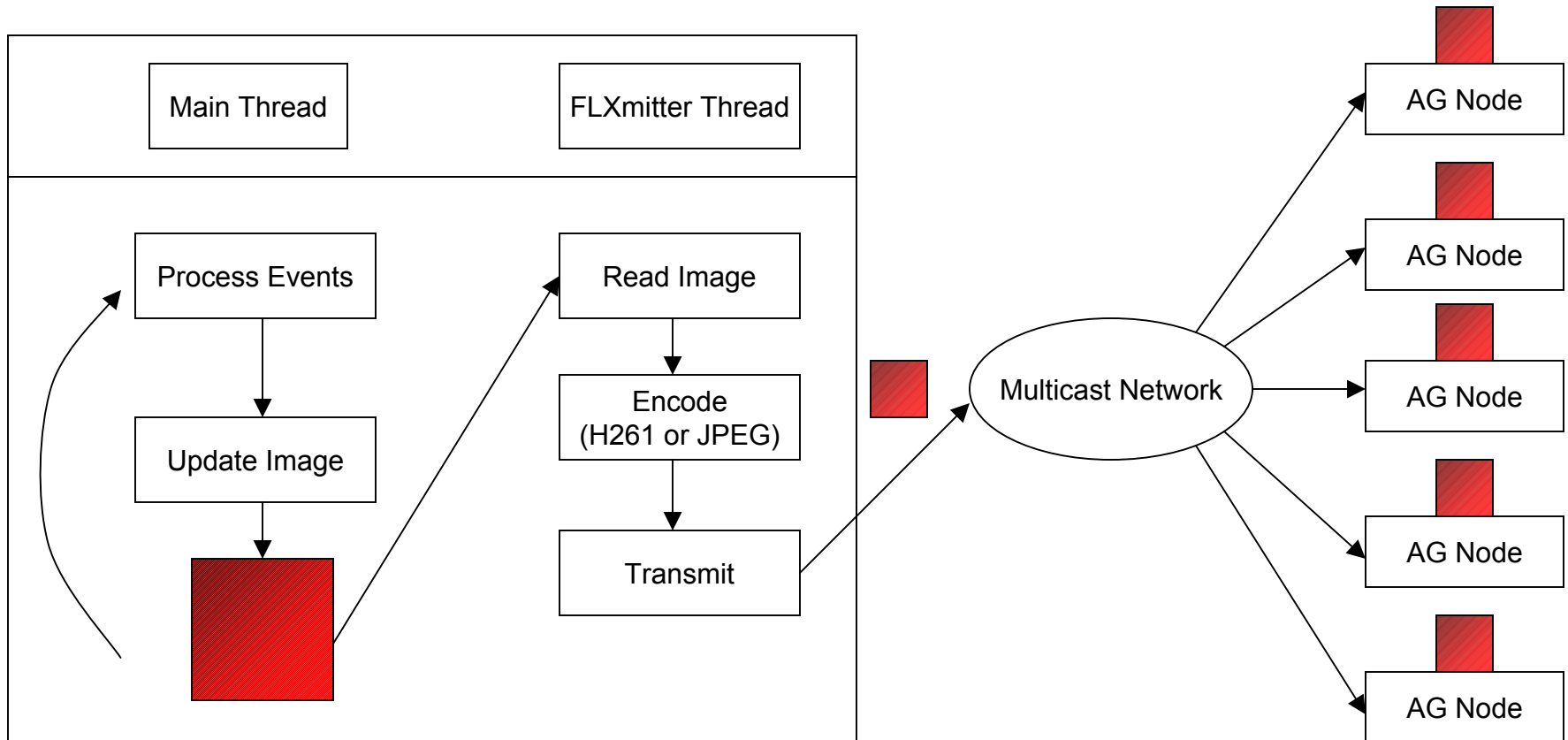 - Responds to *load* requests by retrieving data from the venue and passing it to the Visualization Server

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Distributed Medical Visualization: Client Component

- Customized VIC Client
  - Modified OpenMASH VIC tool
  - Bonds multiple video streams to support high-resolution visualization
  - Captures mouse and keyboard events to allow client interaction

- Client-side AG integration component / visualization GUI
  - Provides AG integration, retrieving startup data and allowing for 'one-click' startup from the venue client
  - Provides a 'filter' for mouse/keyboard events from VIC client, to reduce event processing or provide explicit floor control
  - Provides GUI interface for additional configuration options

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System Flow

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Example Layout (3x2)

Cr Servers

AG Sites

App Node

Tilesort SPU

FLX SPU

FLX SPU

FLX SPU

FLX SPU

FLX SPU

FLX SPU

Multicast Network

vic

vic

vic

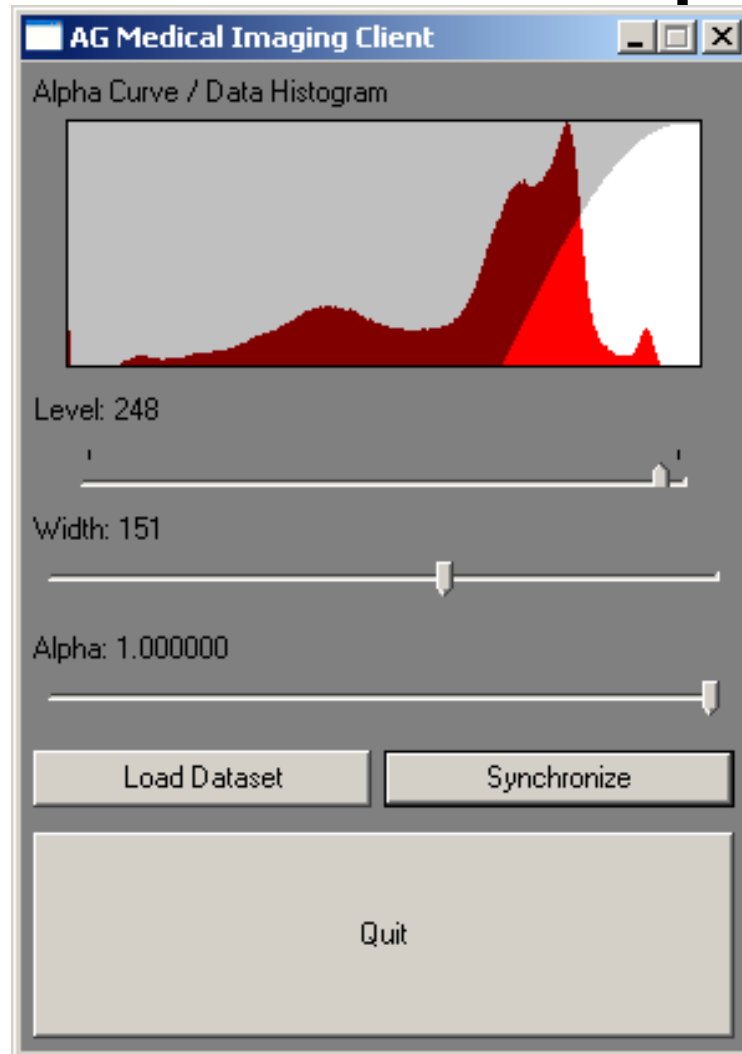Argonne National Lab

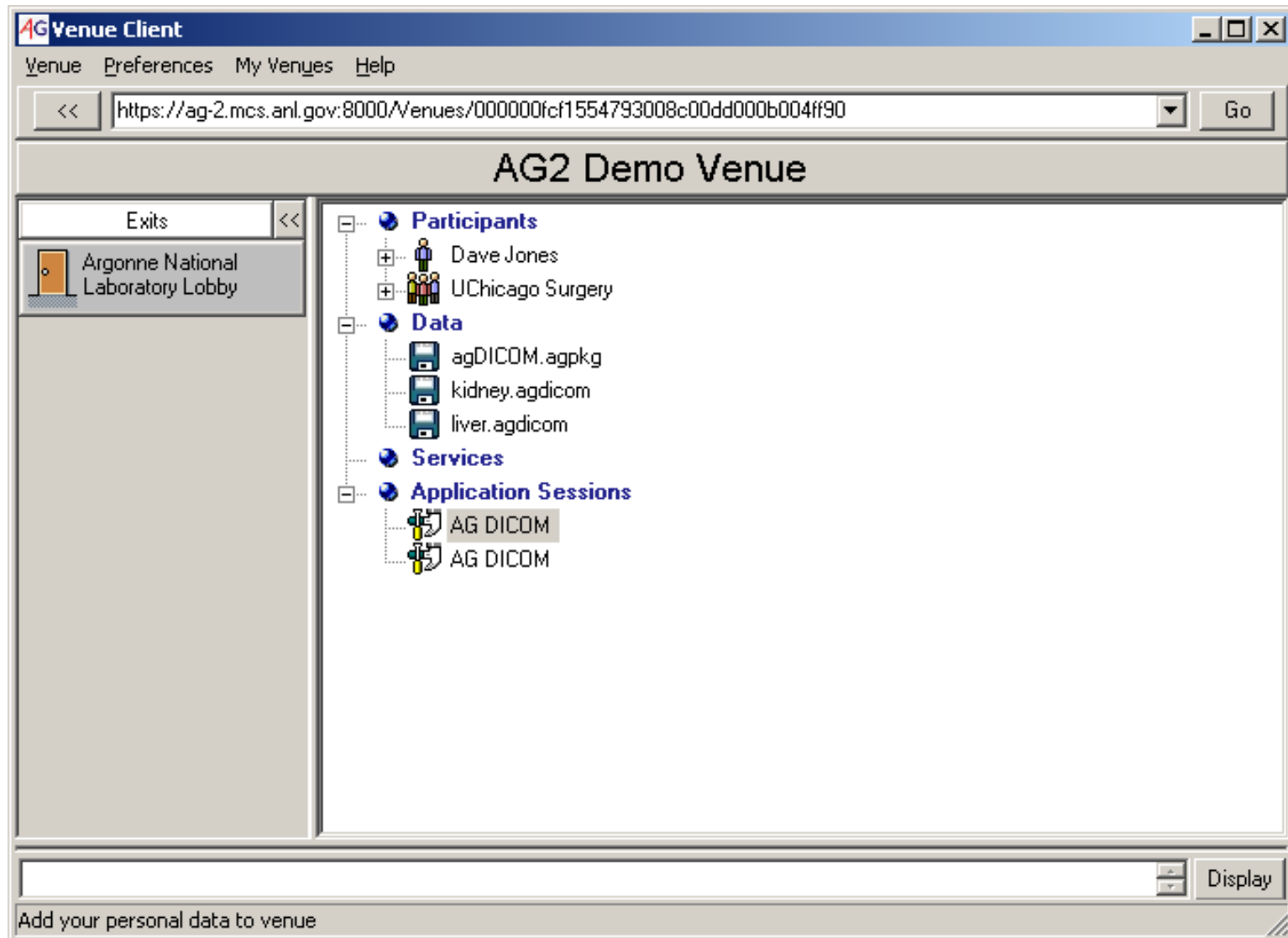University of Chicago
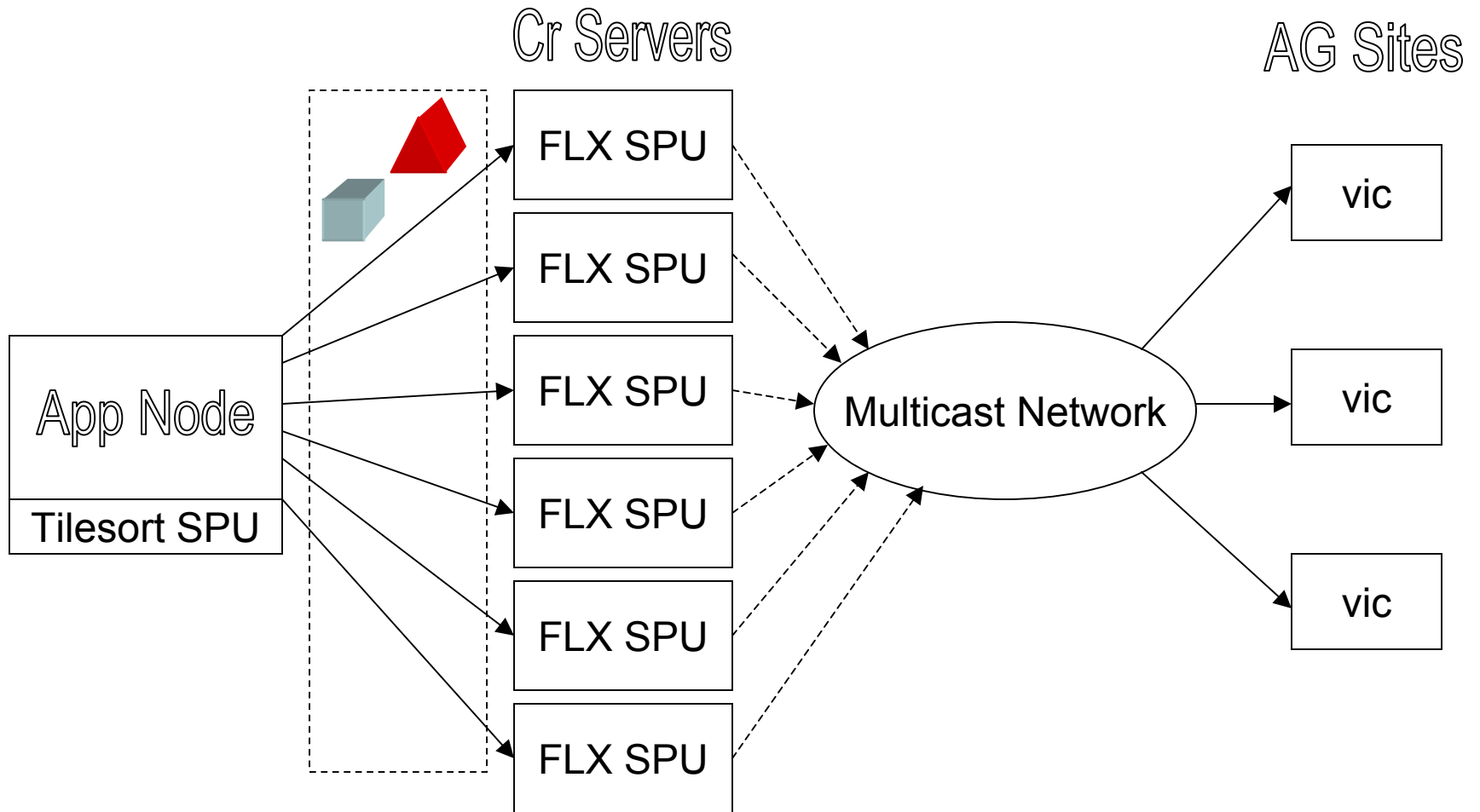
Access Grid Medical Visualization Features Implemented

- Persistent Server-Client Tele-Collaboration
  - Distributed application control, Synchronization, Audio and video channels sharing

- Transparency

- Translate, Rotate, Scale

- Segmentation

- Region of Interest

- Arbitrary Clipping Plane

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Screenshot of Simple GUI

Screenshot of Venue Client

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Conclusions

- The Access Grid is increasingly affordable.
- Collaborative visualization is increasingly important to biomedical research, education, and clinical care.
- Shared AG Applications make distributed collaborative biomedical visualization more feasible (among groups in the same institution and across geographically diverse institutions).
- Medical Centers may find AG technologies essential.

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Future Work

- Expand file input features, including support for standard and time-dependent DICOM studies, pre-segmented data, etc...

- Deploy alternate renderers including parallel rendering.

- Make this type of application update faster with higher resolution data.
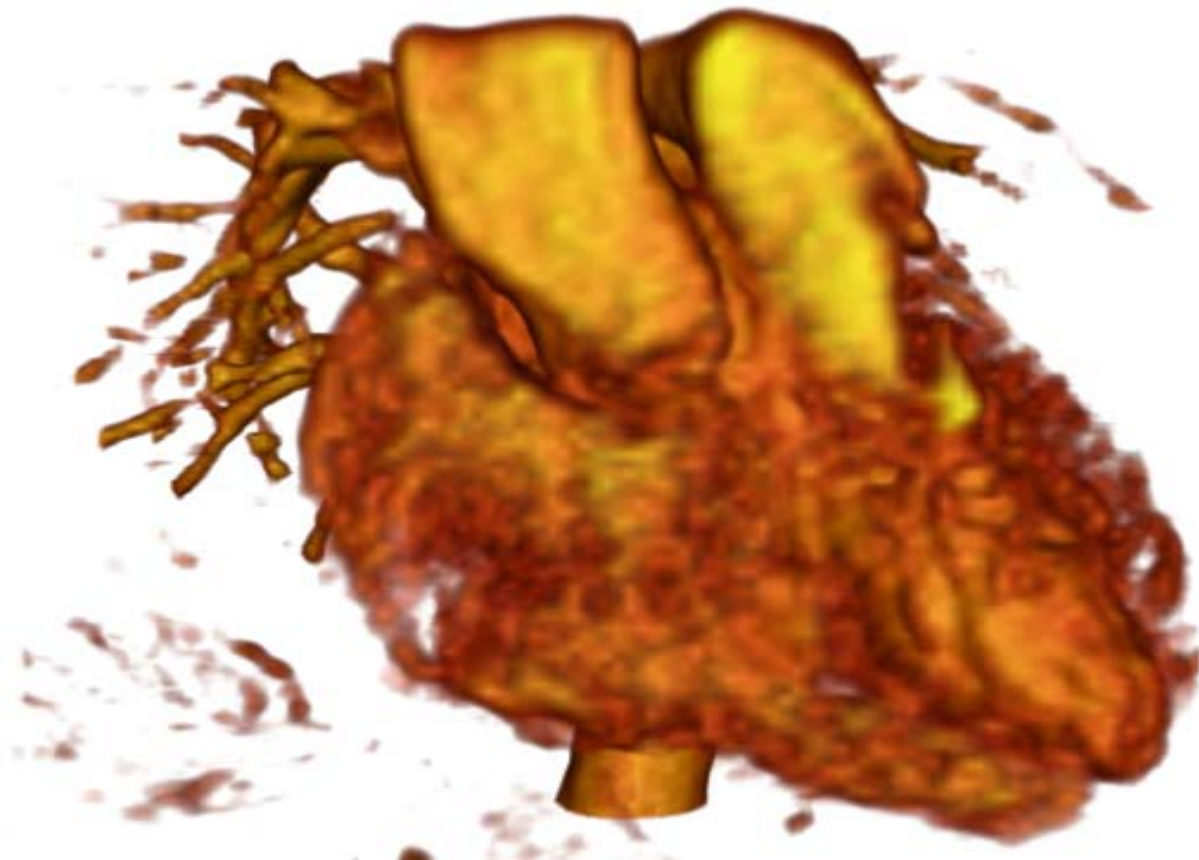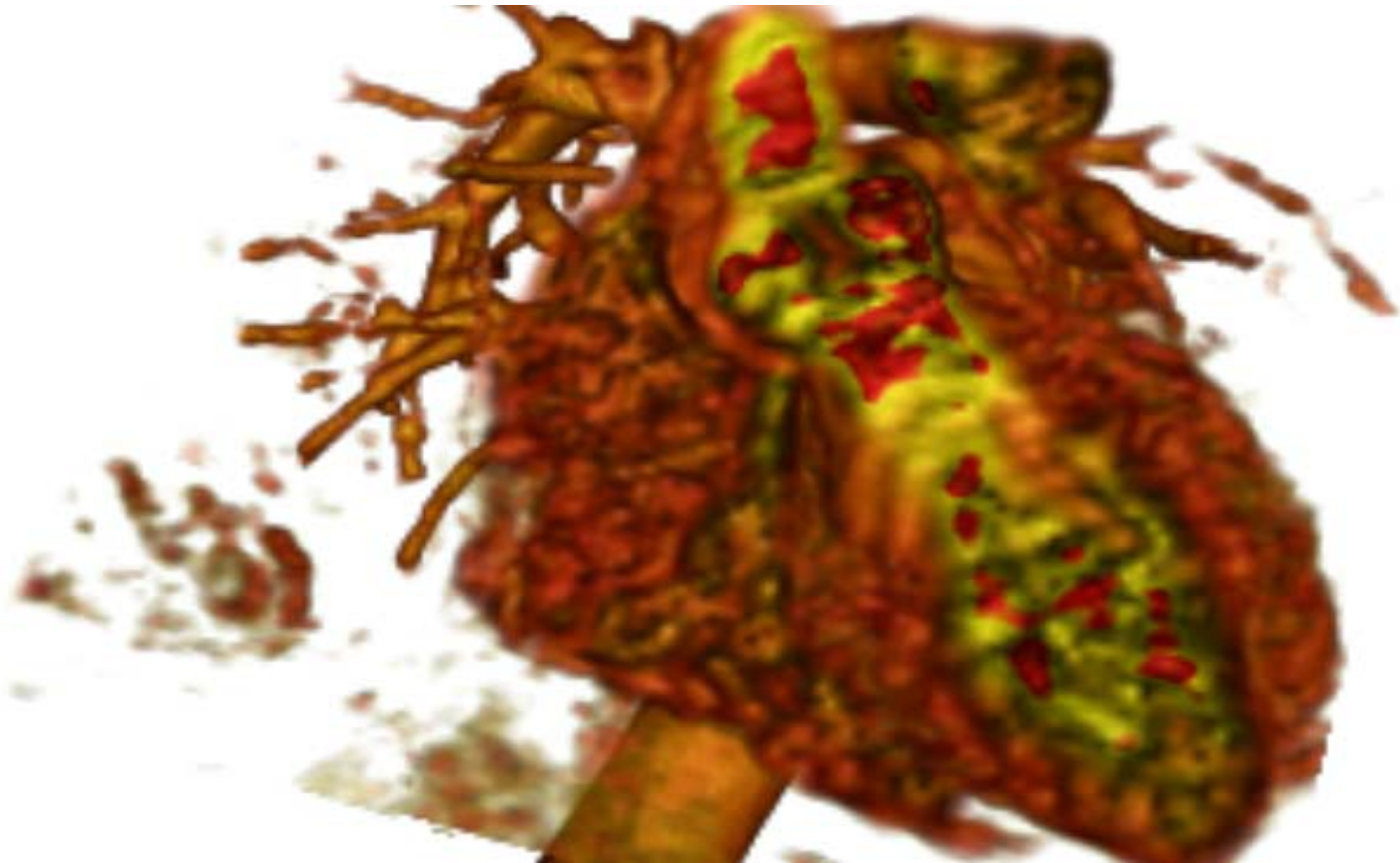
- Deploy stereo rendering for nodes that support it.

Questions?

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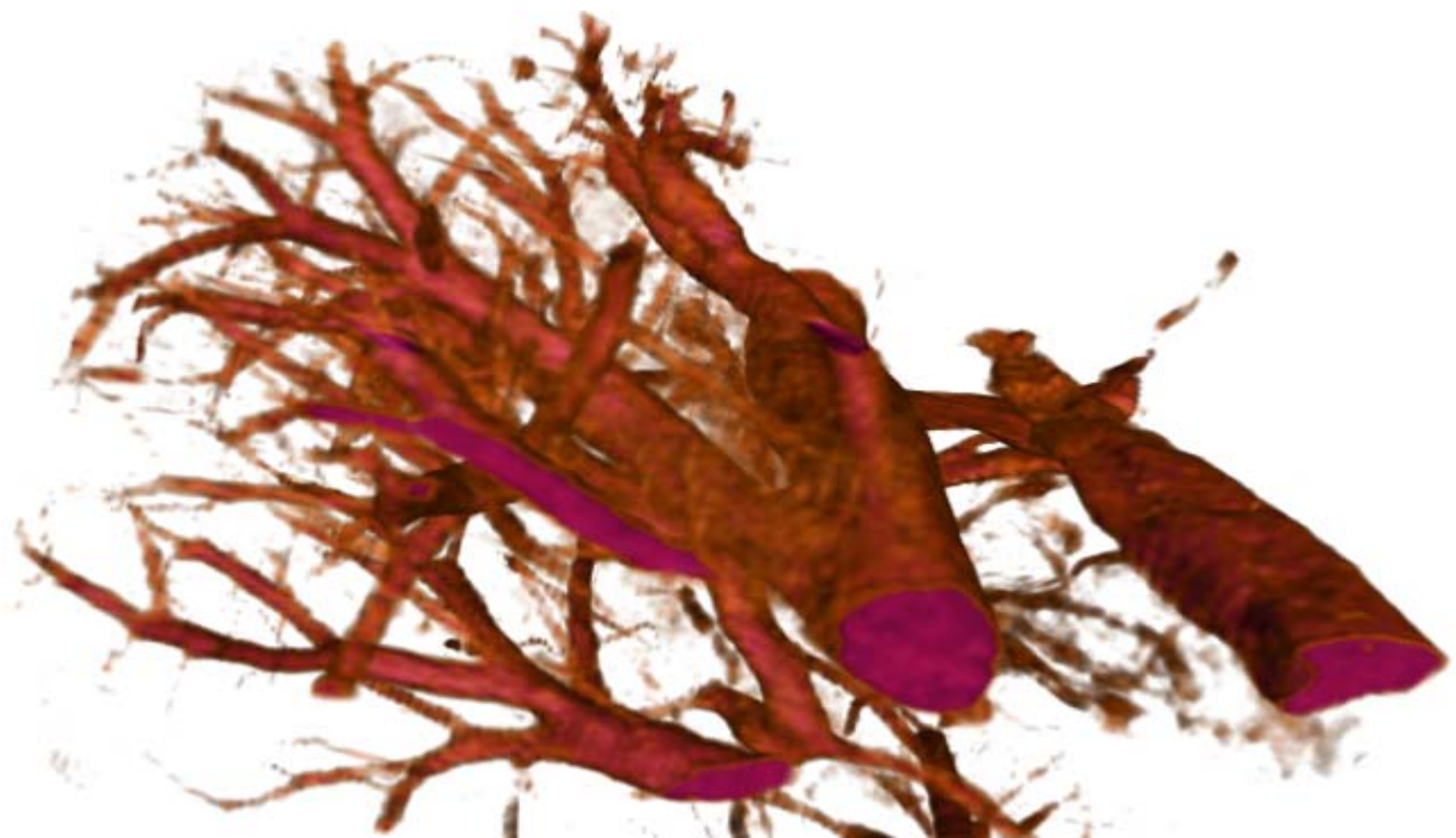Argonne National Lab   University of Chicago

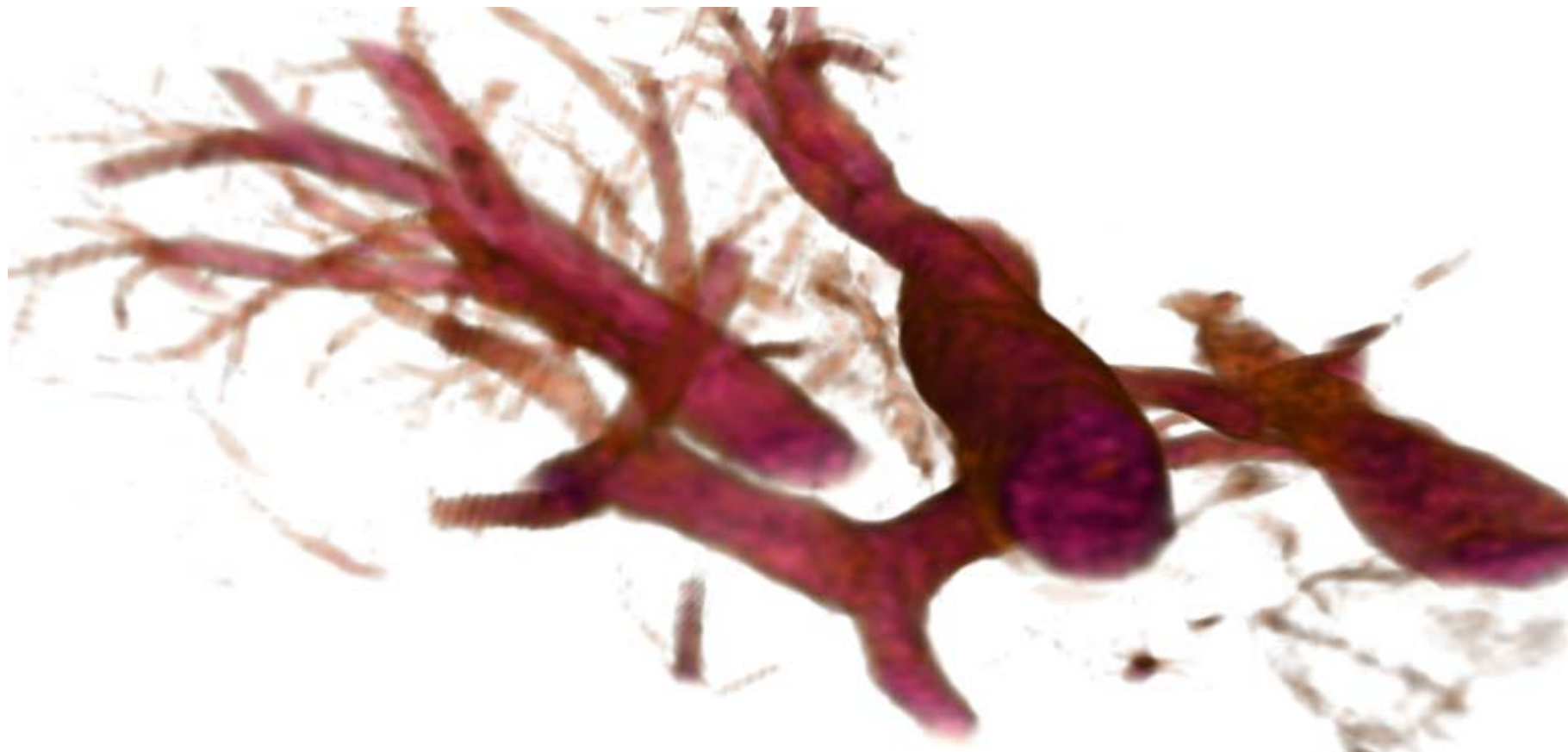Argonne National Lab   FUTURESLAB   Ci   ABC   University of Chicago

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